INVESTIGATION OF THE EXCITED HYDROGEN RADIOLINE

IN THE 5 CM WAVELENGTH WITH THE AID OF A

QUANTUM PARAMAGNETIC AMPLIFIER

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A. F. Dravskikh
Z. V. Dravskikh
V. A. Kolbasov
.... & .....
V. B. Shteynshleyger

[USSR]

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Z. V. Dravskikh
V. A. Kolbasov
G. S. Misezhnikov
D. E. Nikulin
V. B. Shteynshleyger

SUMMARY

This paper describes the 1964 investigations having corroborated the presence of the excited hydrogen line in the 5 cm wavelength, and allowed the photographing of its profile in the Omega nebula.This has been made possible only by utilizing a quantum paramagnetic amplifier.

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N. S. Kardashev had indicated the possibility of observing a series of lines in the radiowave band, emitted by regions with ionized hydrogen, since 1959. (see [1]). Since the ionized hydrogen is more closely linked with the stars than the neutral hydrogen, the study of its radiolines may complement our knowledge of the structure of the Galaxy and of the Universe surrounding us. Attempts to observe excited hydrogen radiolines were made in Pulkovo already in 1958 [2]. The first successful venture in detecting radiolines of excited hydrogen at 5 cm wavelength in the emission of hot nebulae was undertaken by two of the co-authors in 1963 [3].

The investigations conducted in 1964 have confirmed the presence of the radioline and allowed the taking of its profile in the Omega nebula. It became possible only when using a paramagnetic amplifier.

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* ISSLEDONANIYE RADIOLINII VOZBUZHDENNOGO VODORODA NA VOLNE 5 CM S PRIME-NENIYEM KVANTOVOGO PARAMAGNITNOGO USILITELYA.

A quantum paramagnetic amplifier (QPA) of a travelling wave in the 5-cm band is utilized in the radiometer. It operates with liquid helium temperature of 4.2°K [4] with an amplification factor $G = 25$ db for a pass-band $\Delta f = 26$ Mc/s. In it a quantum jump in ruby is utilized between the energy levels $1 - 4$ for pumping and $1 - 2$ for signal, contrary to those utilized in [5]; this allowed the operation without helium vapor exhaustion. The use in the QPA of a wide-band decelerating system (comb) with a built-in low-temperature ferrite valve, assures the possibility of frequency changeover (150 Mc/s) and diminishes the dependence of QPA's amplification factor on the impedance variation at its input by comparison with QPA's resonator, and — matter of great importance in radioastronomy — it provides a high amplification stability (the amplification's instability constitutes less than 0.05 db/sec). The measured aggregate noise temperature of the radiometer with the QPA constitutes 32° K, of which 18° K are superheterodyne balanced receiver's noises (converted to QPA input). The total antenna noise temperature (with a waveguide loop), together with those of the ferrite commutator and of the radiometer, constitutes 116° K. The radiometer's fluctuation sensitivity (with the QPA) is $\delta T = 0.035^{\circ}$ K for a $\Delta f = 20$ Mc/s pass-band and a time constant $\tau = 3.5$ sec, which is somewhat less than the theoretically possible value. A magnetic field of $H = 4000$ oe intensity is induced by a constant magnet. A metallic cryostat of capacity near 5 liters liquid helium is used for cooling the QPA, which assures its continuous operation during 8 hours.

The radiospectrograph utilized for observations constitutes a radiometer of modulation type with a triple frequency transformer, a third heterodyne retuning and consecutive spectrum analysis. The quadratic detector is followed by a balanced amplifier of low frequency and by a standard radioastronomical output.

The observations of the Omega nebula with the view of taking down the radioline $\lambda \approx 5$ cm, were conducted in May and June 1964 with the aid of the radiospectrograph equipped with the above-described QPA. The contour-analyzer pass band constituted 280 kc/s in both cases. In the first case the nebula's emission spectrum was compared with that of the atmosphere and the Earth, and was analyzed in the 5.5. Mc/s band, and in the second

case it was compared with the emission spectrum of the extragalactic source **Cygnus - A** and analyzed in the 3.5 Mc/s band. Comparable results were obtained in both cases.
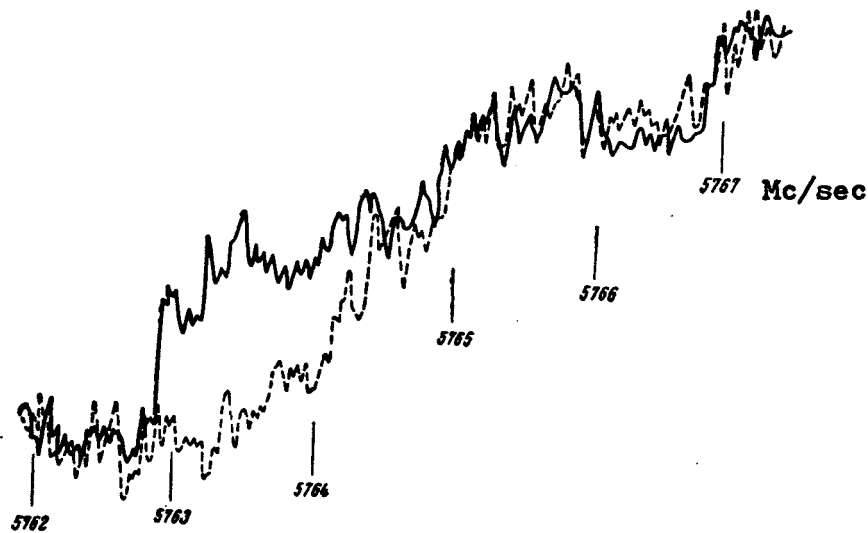

5767 Mc/sec

5766

5765

5764

5762   5763

Fig. 1

In Fig. 1 we present the unique recording made in May with a time constant $\tau = 3.5$ sec. The dashed curve represents the spectrogram of atmosphere and Sun's emission, and the solid curve — that of the Omega nebula. The spectrograms are superposed by the frequency axis. In the frequency region 5763 Mc an increased emission in the nebula spectrum is clearly seen.

We brought out in Fig. 2a (next page) the frequency dependence of nebula emission flux spectral density ratio to that in a continuous spectrum; the curve was obtained by way of averaging four spectrograms, taken down in May. In Fig. 2 δ, this curve is averaged by contour-analyzer width.

Represented in Fig. 3 is a spectrogram similar to that of Fig. 2 δ, obtained in July 1964. The radiowave intensity in the maximum constitutes 3.8 ± 0.5% of the intensity of the continuous spectrum. The width of the line by the half-intensity level constitutes 1.2 ± 0.3 Mc/s. The line maximum position by frequency must periodically shift on account of the

Doppler effect linked with Earth's rotation about the Sun. This shift is revealed.
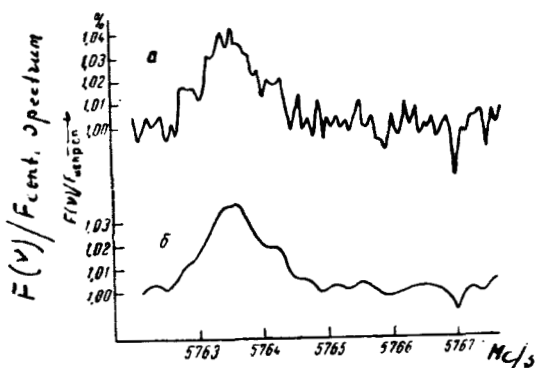

Fig. 1

Fig. 3

In Fig. 4 we presented the curve of sinusoidal variation of the line maximum as a function of the time of the year, obtained on the basis of optical data. Our measurements of the line maximum frequency are shown by dots.

Fig. 4

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*** THE END ***

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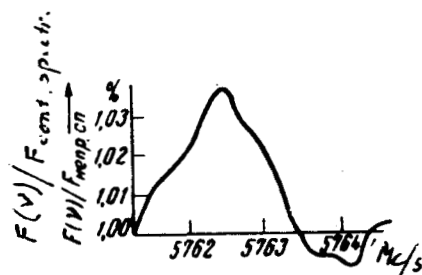[5].- R. W. DeGRASSE, E. O. SCHULTZ DU BOIS, H. E. D. SCOVIL. Bell Syst. Techn. J. 38, 2, 305, 1959.
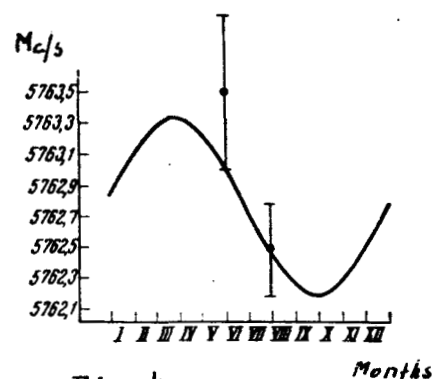
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